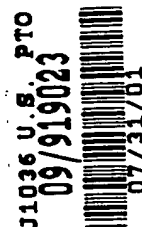




The Patent Office
Concept House
Cardiff Road
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NP10 8QQ



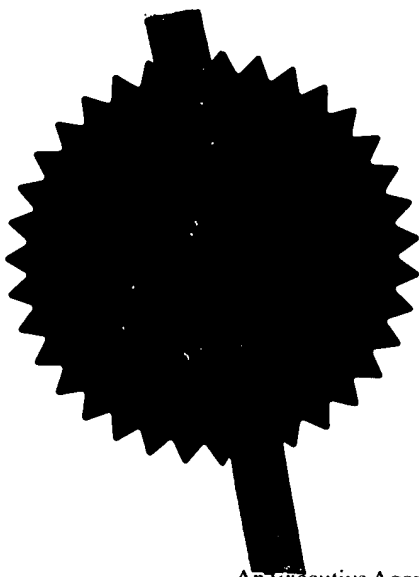
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Signed

W. Evans

Dated

11 May 2001

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The Patent Off

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference

X. CHEN 18-3

2. Patent application number

(The Patent Office will fill in this part)

0020585.6

3. Full name, address and postcode of the or of each applicant (*underline all surnames*)

LUCENT TECHNOLOGIES INC
600 Mountain Avenue
Murray Hill
New Jersey 07974-0636
United States of America

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

Delaware/USA

4. Title of the invention

A METHOD OF SUPPORTING SEAMLESS HAND-OFF IN A MOBILE
TELECOMMUNICATIONS NETWORK

5. Name of your agent (if you have one)

C.S.T. BUCKLEY

**"Address for service" in the United Kingdom
to which all correspondence should be sent
(including the postcode)**

LUCENT TECHNOLOGIES UK LIMITED
5 Mornington Road
Woodford Green
Essex IG8 0TU
England

Patents ADP number (if you know it)

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number
(if you know it)

Date of filing
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing
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8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or

YES

c) any named applicant is a corporate body.
See note (d))

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Continuation sheets of this form

Description 5

Claim(s) 2

Abstract 1

Drawing(s) 1 x 1 M

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Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77) 1

Request for preliminary examination and search (Patents Form 9/77) 1

Request for substantive examination (Patents Form 10/77) 1

Any other documents
(please specify)

11. I/We request the grant of a patent on the basis of this application.

Signature

Date

11th August 2000

12. Name and daytime telephone number of person to contact in the United Kingdom

C.S.T. BUCKLEY

020 8504 2824

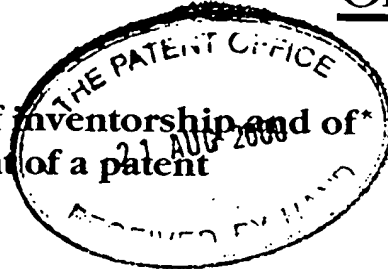
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Statement of inventorship and of
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The Patent Office

Cardiff Road
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Gwent NP9 1RH

1. Your reference

X. CHEN 18-3

2. Patent application number
(if you know it)

21 AUG 2000

0020585.6

3. Full name of the or of each applicant

LUCENT TECHNOLOGIES INC

4. Title of the invention

A METHOD OF SUPPORTING SEAMLESS HAND-OFF IN A MOBILE
TELECOMMUNICATIONS NETWORK

5. State how the applicant(s) derived the right
from the inventor(s) to be granted a patent

As employers

6. How many, if any, additional Patents Forms
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I/We believe that the person(s) named over the page (and on
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which the above patent application relates to.

Signature

Date

11th August 2000

8. Name and daytime telephone number of
person to contact in the United Kingdom

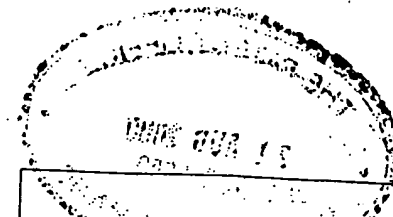
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Enter the full names, addresses and postcodes of the inventors in the boxes and underline the surnames



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Reminder

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Patents ADP number (if you know it):

A METHOD OF SUPPORTING SEAMLESS HAND-OFF IN A MOBILE TELECOMMUNICATIONS NETWORK

5

This invention relates to a method of supporting seamless hand-off in a mobile telecommunications network, especially to hand-offs to a roaming mobile terminal in the network..

In third generation telecommunications networks such as GPRS (General
10 Packet Radio Service) and EDGE (Enhanced Data-rate for GSM Evolution), when a mobile terminal moves into a foreign network, network connectivity is optionally maintained by the use of Mobile Internet Protocol (Mobile IP). In the home network, a Home Agent (HA) is set up which maintains the location information of the mobile by use of Binding Updates, i.e., registration of information sent to the HA by the mobile
15 node.

Mobile IP has two working modes. The first is illustrated in Figure 1; a mobile terminal is currently attached as a Mobile Node (MN) 14 in a network different from its home network. The MN 14 is communicating with a Correspondent Node (CN) 12.

A Home Agent 16 is set up in the home network by the CN 12, and a Foreign Agent
20 (FA) 18 is set up in the foreign network. The FA 18 allocates a unique IP address for the visiting mobile, a Care of Address (COA) and this address is sent to the HA 16 in a Binding Update.

Packets for the mobile are encapsulated by the HA 16 and tunneled along
tunnel 20 to the FA 18 for transmission to MN 14. In such encapsulation, an extra IP
25 header is added to each packet, including the COA of the MN 14. This is known as FA-COA working mode.

In the second working mode (not illustrated) there is no FA, the MN 14 is allocated a unique COA and encapsulated packets are tunneled by HA 16 directly to MN 14; this is known as Collocated Care of Address mode of working (CO-COA).

30 In a conventional packet switched network, when a host A sends a packet to another host B, host A needs to determine the Media Access Control (MAC) address of host B so that the packet can be delivered to the correct physical address in layer 2. Host A sends a MAC broadcast frame, called an Address Resolution Protocol (ARP) request frame, which contains the host A's IP and MAC addresses and the IP address
35 of host B. All nodes in the local network receive the broadcast IP request frame, and

compare the destination address with their own IP address. Only the node with the correct IP address of the ARP request responds by sending a ARP reply containing its MAC address. On receiving the ARP reply, host A updates its ARP cache, which usually times out periodically. After an ARP cache entry has timed out for a specific
5 host, the ARP request is sent again to discover the MAC address of the destination. The ARP cache is consulted by a host before it sends an ARP request, and if the answer is found in the cache, the host does not need to generate an ARP request.

It is known to provide a proxy ARP which is an ARP reply sent by one node on behalf of another node which is unwilling or unable to answer its own ARP requests.
10 The sender of a proxy ARP reverses the sender and target protocol address fields and supplies some configured MAC address (generally its own) in the sender hardware address field (the place-holder field). The node receiving the reply then associates this link-layer address with the IP address of the original target node, so that future packets for this target node are transmitted to that MAC address.

15 When a mobile roams it maintains connectivity by the use of a unique IP address allocated to it, a Care-of-Address, as explained above. By use of Mobile IP, a packet sent from a correspondent node to a mobile node can still use the home address of the mobile node no matter where the mobile moves to. The packet received in the foreign network needs to bear the current Care of Address of the mobile as the destination
20 address. If applications running on the mobile node still use the home address of the mobile, there is seamless mobility support to those applications; the applications do not have to stop and re-start as the mobile roams.

However, before the packet can be sent from the last routing switch in the foreign network to the current Care of Address from the mobile, the routing switch
25 needs to know the MAC address of the mobile. In the current functional specifications of ARP and of Mobile IP, this entry cannot be created. Referring again to Figure 1, in the terms used above, either CN 12 or MN 10 can be host A, the other being host B. In either direction, packets passed through the network from router to router, and in Figure 1 two routers 22, 24, are shown schematically adjacent the optimized route 20.
30 Suppose packets are passing from CN 12 to FA 16 via routers 22, 24; before a packet can be sent from router 24 to the current Care of Address of MN 10, router 24 needs to

know the MAC address of MN 10, as stated above.

The routers 22, 24 can alternatively be associated with the encapsulated route 18.

It is the object of the invention to provide a method of supporting seamless
5 hand-off in a mobile telecommunications network of the type described above.

According to the invention, in a third generation mobile telecommunications network, a method of delivering packets in layer 2 to a mobile terminal in a foreign network comprises the steps of:-

- providing an Address Resolution Protocol (ARP) entity;
 - 10 setting up a home agent in the home network; and
 - allocating a Care of Address to the mobile node;
- characterized by the further steps of:
- setting up a proxy ARP entity; and
 - informing the proxy ARP entity of the Care of Address and the Media Access
 - 15 Control address of the mobile node.

In the invention, in addition to the proxy ARP entity, a Dynamic Host Configuration Protocol (DHCP) can also be used. The proxy ARP server can be built into the DHCP server, or it can be in a stand alone node. The proxy ARP is informed
20 of the Care of Address and the MAC address of the MN 10; this can be achieved during the mobile node registration process; either the proxy ARP advertises itself and receives a registration reply from the MN 10, or the MN 10 solicits the proxy ARP by broadcasting a proxy ARP soliciting request, and the proxy ARP replies to confirm the registration.

25 The foreign network proxy ARP controls operations in two different cases, when there is transmission from CN 12 to MN 10, and when there is transmission in the opposite direction.

In the first case, transmission from CN 12 to MN 10, when the working mode is COCOA mode, when a packet from the CN 12 arrives at the last routing switch of the
30 foreign network, i.e. switch 24, the switch broadcasts an ARP request, with the frame format:-

Sender's MAC	Sender's IP address	MN's MAC (NULL)	MN's COA
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The proxy ARP receives the broadcast message and compares the receiver's IP address with the registered Care-of-Address of the MN 10. If a match is found, the proxy ARP sends an ARP reply message having the format:-

MN's MAC	MN's COA	Sender's MAC	Sender's IP address
----------	----------	--------------	---------------------

5

When the switch 24 receives the ARP reply, it updates its ARP cache table by adding an entry with the unique mapping between the Care-of-Address and the MAC address of MN 10. The switch 24 can then successfully deliver the packet to MN 10 at the correct address in layer 2.

10 When the working mode is FA COA mode, the FA 16 replies to any request for its MAC address, sending the FA COA as the IP address of the mobile node.

In the second case, transmission from MN 10 to CN 12, there is a preliminary stage. Before a packet is sent by MN 10, the ARP module in MN 10 or the daemon running in MN 10 checks whether the destination of the packet (i.e. CN 12) is a node
15 which is local to the home network of the MN 10. If the destination is in the home network, then the MN 10 broadcasts its ARP request using its own home IP address as the sender's address. The ARP request format is:-

MN's MAC	MN's Home IP Address	CN's MAC (NULL)	CN's IP Address
----------	----------------------	-----------------	-----------------

When the proxy ARP receives the ARP request, it responds by sending an ARP
20 reply message to the MN 10 in the format:-

FN Default Gateway's MAC	CN's IP Address	MN's MAC	MN's IP address
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Consider now the position when the destination is not in the home network of MN 10.

In the foreign network (FN) there is a Default Gateway; this Default Gateway broadcasts an ARP request message and the proxy ARP server learns the IP address of the foreign network Default Gateway by receiving this message. The MN 10 broadcasts an ARP request using the Default Gateway in the foreign network as the destination IP address. The ARP request format is:-

MN's MAC	MN's Home IP Address	FN's Default Gateway MAC(NULL)	FN's Default Gateway's IP address
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When the proxy ARP receives the broadcast, it sends an ARP reply message to the MN 10 in the format:-

FN Default Gateway's MAC	FN Default Gateway IP Address	MN's MAC	MN's Home IP Address
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The packet can therefore be successfully delivered to the CN 12.

In another variation, the ARP proxy can be built as a daemon running in the MN 10, care being taken that it does not affect the standard ARP daemon in the MN 10.

By application of the method according to the invention, seamless hand-off can be achieved even when a mobile is roaming in a foreign network.

CLAIMS

1 In a third generation mobile telecommunications network, a method of delivering packets in layer 2 to a mobile node (10) in a foreign network comprises the steps of:-

5 providing an Address Resolution Protocol (ARP) entity;
setting up a home agent (14) in a home network of the mobile node;
allocating a Care of Address to the mobile node (10); and
setting up a Dynamic Host Configuration Protocol (DHCP); characterized by the further steps of:

10 setting up a proxy ARP entity; and
informing the proxy ARP entity of the Care of Address and the Media Access Control address of the mobile node.

2 A method according to Claim 1 in which packets are transmitted from the correspondent node (12) to the mobile node (10) and the Care of Address is a
15 Collocated Care of Address comprising the further steps of:-

a last routing switch (24) in the foreign network broadcasting an ARP request;
the proxy ARP responding with an ARP reply message containing the MAC address of the mobile node (10);

the last routing switch (24) updating its ARP cache table by adding a unique
20 mapping between the Care of Address and the MAC address of the mobile node (10);
and

the last routing switch (24) delivering the packet to said MAC address.

3 A method according to Claim 2 in which the ARP request from said last routing switch has the frame format:-

25 Sender's MAC; Sender's IP address; MN's MAC (NULL); MN's COA;
and the ARP reply from the proxy ARP server has the frame format :-

MN's MAC; MN's COA; Sender's MAC; Sender's IP Address.

4 A method according to Claim 1 in which packets are transmitted from the mobile node to the correspondent node comprising the further steps of the ARP
30 entity checking whether the destination of the packets is a node in the home network of the mobile node, and if so, the mobile node sending an ARP request using its own home

IP address as the sender's address; and the proxy ARP responding with a ARP reply addressed to the MN's IP address.

5 A method according to Claim 4 in which the ARP request from the MN has the frame format:-

5 MN's MAC; MN's Home IP Address; CN's MAC (NULL); CN's IP address; and the ARP reply from the proxy ARP server has the frame format:-

FN Default Gateway's MAC; CN's IP Address; MN's MAC; MN's IP address.

6 A method according to Claim 4 in which the destination of the packets is a node which is not in the home network of the mobile node, comprising the further
10 steps of the mobile node sending an ARP request using the MAC address of a Default Gateway in the foreign network as the sender's address;

the Default Gateway receiving the ARP request and broadcasting it; and

the proxy ARP responding by sending an ARP reply to the MN.

7 A method according to Claim 6 in which the ARP request from the MN
15 has the frame format:-

MN's MAC; MN's Home IP Address; HN's Default Gateway (NULL); HN's Default Gateway's IP address;

and the ARP reply from the proxy ARP server has the frame format:-

20 FN Default Gateway's MAC; HN Default Gateway's IP Address; MN's MAC; MN's Home IP Address.

ABSTRACT

A METHOD OF SUPPORTING SEAMLESS HAND-OFF IN A MOBILE TELECOMMUNICATIONS NETWORK

5 To deliver packets to the MAC of a roaming mobile in a seamless manner, a proxy ARP is set up, in addition to the usual ARP, and is informed of the COA and MAC address of the mobile. The proxy ARP then informs the last routing switch in the foreign network of the MAC address of the mobile.

10

Figure 1

